Diminished transparency of the atmosphere for considerable periods is not unusual. The meteorological conditions are frequently such that during an entire month there will not be a single day with a clear sky. But where such a variety of observations show a turbid condition of the atmosphere for several successive months, and even on days when meteorological conditions are favorable for a clear sky, some other explanation is necessary. In the case under consideration this is supplied, as indicated by Marchand, by the great quantities of volcanic dust thrown out by the eruptions in the West Indies during May, 1902.

TWILIGHT GLOWS AND CONNECTED PHENOMENA OBSERVED IN 1902, 1903, AND 1904 IN THE PYRENEES.

By E. MARCHAND.

[Translated by Miss R. A. Edwards, from the Annuaire de la Société Météorologique de France, February 1905, p. 40-45.]

I will summarize here, very briefly, the observations made on these phenomena at Pic du Midi or at Bagnères, by my coworkers, Messrs. Ginet, Latreille, Dort, and myself, since the end of the year 1902; observations which have been communicated at different times to the Société Ramond, principally in the meetings of February 3, and April 7 and 12, 1904.

Three principal phenomena have been distinguished which can be attributed, nevertheless, to the same general cause, the presence of dust, or perhaps of extremely fine particles of ice, in the upper regions of the atmosphere, the dust coming probably from the great eruptions of the volcanoes of the Antilles in May, 1902. These three principal phenomena are: (*a*) twilight glows; (*b*) solar or lunar coronas; (*c*) diminution of solar radiation. And we shall have occasion to mention several others of less importance.

(*a*.) TWILIGHT GLOWS.

Two phases of this phenomenon may be distinguished; (1) The appearance, fifteen or sixteen minutes after sunset[1] of a first twilight segment, pink, purplish, or copper red, which lasts from twenty to twenty-five minutes and then disappears below the horizon, leaving but a more or less persistent band of red or orange. The phenomena are naturally reversed when one observes in the morning before sunrise. (2) The appearance, about fifteen minutes after the disappearance of the first segment, of a second segment, pink or copper red, occupying about the same position, and disappearing in the same manner, but remaining sometimes much longer than the first.

The first segment is not peculiar to the period 1902-1904, during which time it only became much more intense and much more brightly colored. It exists at all times but it was on July 31, 1902, that I found it for the first time at Pic du Midi of an abnormal intensity; an intensity which I observed afterwards at various dates, during August, September, and October; but it was not until the end of October that it attracted the attention of the public.

By observing carefully the angular maximum height of the summit of this colored segment (due to the reflection of the solar rays, tangential to the earth, on the dust of the upper atmosphere) and the corresponding hour, one may calculate the height of the dust above sea level; allowing for refraction, these calculations have given me rather variable numbers, comprised between 10 and 40 kilometers.

The second segment, also, usually exists; but it consists ordinarily of a faint white light and therefore generally passes unnoticed; since the month of October, 1902, it has frequently been of a pinkish tint or copper red, sometimes brilliant and contrasting strikingly with the rest of the sky, which, at this time is very dark.

[1] We have reference here to the astronomical sunset, which may differ somewhat from the real sunset. At Pic du Midi, the real sunset takes place from eight to thirteen minutes after the astronomical sunset, on account of the large depression, 1° 42′, of the sensible horizon.

It is this second segment, when it is colored, that constitutes always, for the public, the twilight glow; it is produced by the solar rays that undergo two reflections on the atmospheric dust.[2]

In other words, one may say that the sun itself is the source of light of the first segment, although it has already set at the place where one observes this segment; while the source of light of the second segment is the colored region of the first segment or horizontal band, which latter is in the horizon of that elevated point in the atmosphere where this second segment is produced.

After August, 1902, the first segment, with its brilliant coloring, was observed several times each month; the second segment was relatively rare and was produced only during groups of two, three, and four days, separated from each other by rather long intervals, sometimes of several months. We must conclude from this that the atmosphere has probably contained a large quantity of dust at a high elevation ever since the latter part of the year 1902, but that it was probably not always abundant enough or elevated enough to be able to produce the second segment.

However, the second phenomenon demands not only the presence of very elevated dust; it is also necessary that the atmosphere be clear to a great distance from the place of observation to the east, for the morning, or to the west, for the evening. This can not occur frequently; therefore, contrary to what certain authors think, the absence of this second segment does not prove the absence of atmospheric dust.

Moreover, other related phenomena, which I will briefly enumerate, go to prove, in their turn, that this abnormal dust has never been absent during two years.

(*b*.) SOLAR AND LUNAR CORONAS—ANTHELIA.

After examining carefully the notes that accompany our observations with the dynamic actinometer and which give exactly the condition of the sky about the sun,[3] I find that the solar corona was clearly perceived for the first time at Bagnères and at Pic du Midi, July 26, 1902, that is, about two months and a half after the great eruptions at Martinique. But it was only beginning with the month of December of the same year that it was seen permanently around the sun, or around the moon during the night. It is still visible whenever the sun shows itself; however, it seemed less luminous in 1904 than during 1903.[4]

This corona is composed of a sort of circular white halo, immediately surrounding the sun, and whose exterior contour is slightly tinted with copper red or purplish pink. The coloration can be seen only by hiding the sun behind an obstacle somewhat distant from the eye, such as a tree, the summit of a house, etc.

The mean diameter of the colored ring, as measured very frequently at Bagnères or at Pic du Midi,[5] was about 48°, varying from 46° to 50°, at the end of 1903; the width of this ring was at that time about 20°; the outer diameter of the corona was about 70°. At the present time the mean diameter appears to be from 40° to 44°; the measurement is difficult, however, especially at the present time, because the colored ring merges insensibly into the white halo of the interior, and into the blue sky of the exterior.

At the close of 1903, we frequently saw in the luminous halo

[2] I wish to state, in the beginning, that I describe always the phenomena visible in the evening; that the words first and second segment relate to the sunset; and that in the morning these phenomena occur in inverse order.

[3] At Bagnères and at Pic du Midi, we take observations every three hours, daily, with a static actinometer and besides, when the state of the sky will permit, with a dynamic actinometer (of a system intermediate between those of Violle and of Crova).

[4] The name Bishop's ring is often given to this corona.

[5] For these measurements and for all those that may have to be made on the phenomena of atmospheric optics, I have devised a special graphometer, very easily used, very convenient, and very easy to construct.

some slight striæ, analogous to the filaments of the cirrus, forming a sort of network and showing to the eye the appearance of a very fine dust, irregularly stratified and lighted; sometimes this same appearance of a dusty network was perceived also at the exterior of the corona, which appeared then much larger (its exterior diameter was, on certain days, 130°, while under ordinary conditions it was about 70°). Finally, I saw this dusty network over almost the whole extent of the sky. These phenomena were not produced in 1904.

In considering the corona as a phenomenon of diffraction caused by atmospheric dust, we find easily that the mean diameter of the particles of dust is about 2.6 μ, or, in round numbers, three-thousandths of a millimeter.

But this corona is not the only phenomenon of diffraction produced by the so-called dust. I will mention another, which has not yet been described and which I observed in 1883 and 1884, at the same time as the Bishop's ring, soon after the terrible eruption of Krakatoa.[6] This is an anthelion altogether analogous to those which are often produced on fogs or clouds at elevated stations, such as Pic du Midi, and to which the name "Specter of the Brocken" is often given.

This anthelion appears in the form of a faintly-colored purplish-pink or copper-red ring of the same diameter and the same width as the colored ring of the solar corona, but visible on the side opposite the sun, or to the east in the evening. I observed it rather frequently during January, February, and March, 1903, very rarely during the following months, and not once during the month of August of the same year.

Quite often the lower part only of the anthelion was visible. When this was the case, the phenomenon assumed the aspect of two columns of purplish light, about 50° apart, slightly curved toward each other (the upper part of the arc being absent) and resting on the pink band which ordinarily surmounts the shadow of the earth.

Finally, on the same dates, the horizon opposite the setting sun often shows over a large extent a faint purplish tint, which commences some minutes after sunset and continues for a variable length of time.

(*c.*) DIMINUTION OF SOLAR RADIATION.

According to the observations made with the dynamic actinometer as often as possible at the two stations of this observatory, it was on May 27, 1902 (that is to say, 20 days after the great eruptions of Mont Pelée), that the first appreciable diminution of the intensity of radiation was recorded, and that, too, simultaneously at Bagnères and at Pic du Midi, without any other apparent cause than the slightly vaporous (hazy) appearance of the sky in the neighborhood of the sun.[7]

But this diminution then ceased. It was observed from time to time during the following months, and became permanent in January, 1903; the diminution then amounted to about one-fifth of the average intensity of insolation that had obtained during preceding years at the same dates and under the same conditions as regards the height of the sun, the temperature, and the humidity.

On February 21 and 22, 1903, at Bagnères, this diminution attained one-half the normal value of the radiation. The atmosphere was then charged with a dust, hiding objects more than six or seven kilometers distant, and rising not more than 2800 meters on the 21st and 2500 meters on the 22d, according to observations taken at Pic du Midi. The comparison of the actinometric observations made at Bagnères and at Pic du Midi during these and the preceding days appears to indicate that the particles of dust scattered in the higher regions of the atmosphere before February 20 fell little by little into the lower regions from the 20th to the 22d because of an exceptionally calm atmosphere. This dust, however, was visible at Bagnères in the form of light stratified clouds, analogous to the cirrus, on the 21st and 22d; at Pic du Midi the atmosphere was clear above 2500 meters and the solar radiation was less diminished. On the 22d and 23d at Bagnères the fall of this dust on the surface of certain zinc roofs was actually observed.

There was still considerable diminution of radiation during February, March, April, May, June, and July, 1903; in August the diminution still amounted to about one-tenth of the normal radiation, during the following months it became less without disappearing altogether; there were, however, some fluctuations. During the year 1904, the actinometer has sometimes given almost normal intensities, while on other days, without apparent cause, it has indicated an atmospheric absorption greater than normal by about one-tenth.

(*d.*) OTHER PHENOMENA.

I shall but mention some other phenomena resulting from the presence of dust in the atmosphere.

(1.) *Diminution of the intensity of the blue of the sky.*—This intensity is measured five times a day, at our two stations, by means of the Saussure cyanometer (scale of 0, white sky, to 50, black or blue-black sky); the diminution of this blueness was three units of the cyanometric scale at the end of 1902 and at the beginning of 1903.

(2.) *Green color of the moon.*—Very often during the same period of 1902–1903 the moon, as seen in a clear sky, had a characteristic greenish tint, and was surrounded by a luminous region of the same color, and outside of that by the halo or corona already described.

(3.) *Pink color of high clouds and of mountain summits.*—I have often observed that high clouds, whose altitudes are known by processes that we employ for this purpose, when located at the zenith, or even to the east of the zenith, were illuminated by a pinkish light a long time after sunset, as if they still received the rays of the sun; that is, as if they were from fifteen to twenty kilometers above the ground. The mountain summits visible from Bagnères (for example, the Peak of Arbizon, 2830 meters high), have sometimes been illuminated in the same way.[8] In reality, this phenomenon is quite analogous to the second twilight segment; the rays that then reach these clouds have been reflected a first time;[9] they are, by contrast with a very dark sky, lighted brilliantly by the light coming from the red band orfrom the first pink segment, which is in their own horizon.

General conclusions.—One may conclude, it seems, from the whole of our observations, that during two years very fine dust was scattered in the higher regions of our atmosphere; that above the Pyrenees this dust was never absent after the month of June, 1902; that the quantity and the altitude of the particles of dust have undergone rather large variations, but have, however, progressively diminished, and finally, that all the abnormal phenomena above described can be attributed to the presence of this dust.

As to the dust itself, it appears to have come from the Antilles, as that of 1883 came from the eruption of Krakatoa, and that of 1831 from the submarine volcano which produced the temporary island "Julia" in the Mediterranean.

It will not be useless to call attention to the fact that the various phenomena mentioned here were already described by the Observatoire du Pic du Midi, almost immediately after their appearance, in the Bulletin mensul du Bureau Central

[6] In the month of December, 1883, I called the attention of the Académie des Sciences to the presence of this diffraction circle [i. e., the Bishop circle.—ED.] and to its connection with the twilight glows of the preceding month. See Paris, C. R., 1883, xcvii, p. 1514.

[7] Although the observers, Messrs. Ginet and Dort, did not note explicitly on this day the presence of a corona around the sun, but only a light vapor or mist in the neighborhood of the sun, it is probable that the corona already existed.

[8] I had made the same observations on the Alps (especially on Mont-Blanc), and at the Observatory of Lyons in 1883 and 1884.

[9] [By the air and vapor and dust.—*C. A.*]

Météorologique du France, viz, the twilight glows in October, 1902, the solar and lunar corona and diminution of radiation in December, 1902, and January, 1903. It is, then, surprising that various scientists, describing them in their turn some months later, or summarizing in 1904 the observations made at various places, have appeared to ignore completely the indications given in an official organ for French meteorology.

These indications were, it is true, very brief, as are those that I have just given, and it would certainly be interesting to publish our observations a little more in detail, as I hope to do soon.

But I desire now to point out the difference of intensity which exists, according to my observations, between the phenomena of 1883–1884 and those of 1902–1903. In 1883 (I then observed at Lyons), the twilight glows (the second segment) were more luminous and more prolonged, and the diffraction circles coronæ or anthelia, were much more brilliant and easy to see than in 1903.

THE SOLAR ECLIPSE OF AUGUST 30, 1905, AS VISIBLE IN THE UNITED STATES.

By WILLIAM FRANCIS RIGGE, S. J., Creighton University, Omaha, Nebr.

The solar eclipse of August 30, 1905, will, as is well known, be a total eclipse. But as the path of totality begins just outside of the United States, the eclipse becomes for us a partial one and occurs near the time of sunrise. A map of this eclipse specially constructed for the United States and showing the varied degrees of obscuration attained in the different States, will, therefore, I trust, be of interest to the reader, and it is accordingly given herewith. (See Fig. 1). This eclipse map was constructed graphically according to the method explained by the writer in Popular Astronomy Nos. 32, 33, 34, of August, September, and October, 1896.

A great part of the sunrise oval lies across the United States. Its eastern branch entitled "Eclipse begins at Sunrise," its middle line showing the "Middle of the Eclipse at Sunrise," and its western branch on which the "Eclipse ends at Sunrise," are sufficiently intelligible not to need any explanation. The smaller ovals marked 2, 4, 6, 8, show the even tenths of obscuration, that is, of the sun's diameter obscured, at the moments of sunrise. For example, all along the oval 6 the sun rises six-tenths eclipsed, along the eastern branch of this oval the eclipse is increasing and along the western branch decreasing at this moment.

The system of lines approximately at right-angles to the middle of the eclipse line denotes every tenth of obscuration for the middle of the eclipse, or, in other words, the maximum obscuration.

A couple of examples will illustrate the use of the eclipse map. At Cincinnati, Ohio, the sun rises with an obscuration of 0.50, and this increases to 0.67. At Omaha, Nebr., the obscuration at sunrise is 0.56 and is diminishing.

The dotted lines marked V, VI, VII, at the bottom of the map, show the places at which sunrise occurs at 5, 6, 7, o'clock, central time. *C* is the point of first contact.

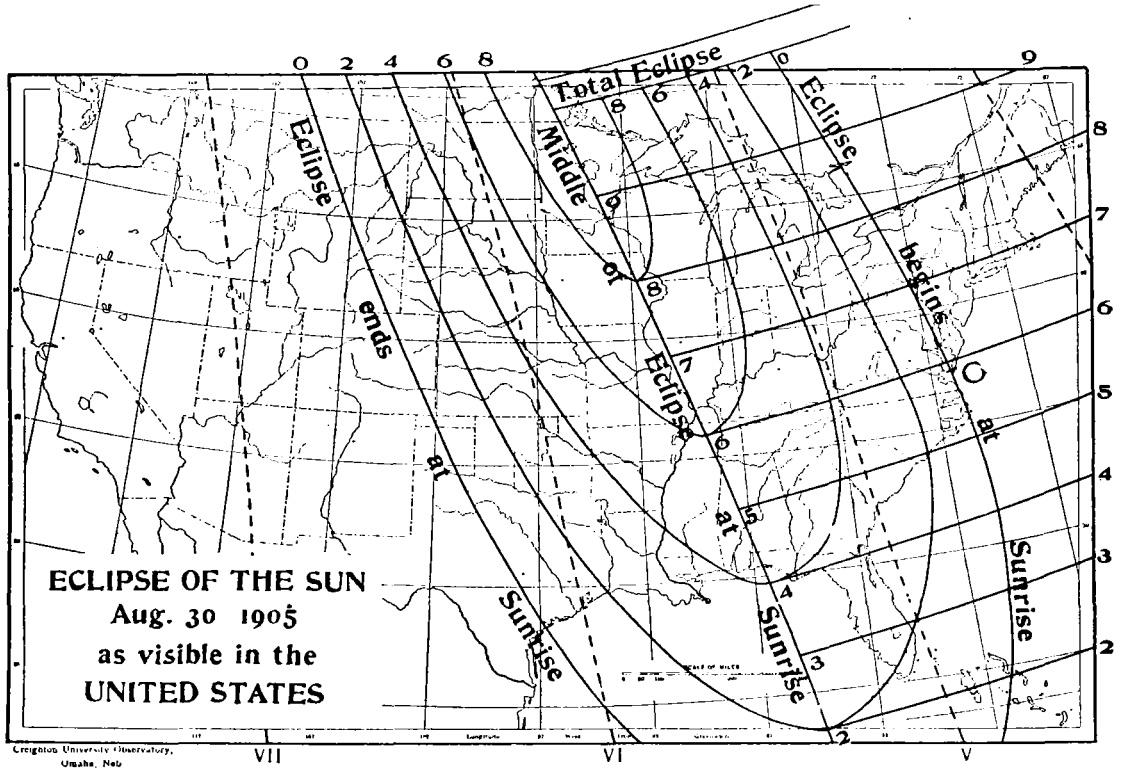

FIG. 1.—Map showing the degrees of obscuration in the different States.

NOTES AND EXTRACTS.

TORNADO NEAR BLUFF SPRINGS, FLA., MARCH 20, 1905.

Mr. William F. Reed, jr., observer at Pensacola, submits a report of a tornado near Bluff Springs, about 40 miles north of Pensacola, early in the morning of March 20. The morning weather map of that date shows an area of low pressure central near Meridian, Miss., with thunderstorms at Pensacola, Mobile, Meridian, Montgomery, and Nashville, and the following heavy rainfalls were reported: Mobile, Ala., 9.20 inches; New Orleans, La., 5.48; Birmingham, Ala., 1.76; Montgomery, Ala., 1.50; Pensacola, Fla., 1.84; Nashville, Tenn., 1.16; Corpus Christi, Tex., 1.06.

Owing to the hour of occurrence, 4 a. m., and its brief duration, the storm was not generally noticed, so far as known. Mr. G. M. Gentry, whose residence was in the path of the storm, furnishes the accompanying sketch, fig. 1, showing